Plan endorsement by private service providers then takes two possible forms:

1. Explicit endorsement and implementation of the plan by a private service provider; or

2. Responding to requests for proposals by local government agencies for services consistent with the plan.

PLAN IMPLEMENTATION

Plan implementation as presented here will take notice of multiple broadband telecommunications networks either being deployed, or expected to be deployed, in the coming years:

1. The Regional Broadband Wireless Network

   - in the 4.9 GHz public safety frequency band

   - in the 5.8 GHz unlicensed commercial frequency band

   - implemented on a county-by-county basis

2. Community-Based Wireless Networks

   - in the 2.4 GHz unlicensed WiFi frequency band

   - implemented on a community-by-community basis

3. Fiber-to-the-Node (FTTN) Wireline Network

   - implemented in the Region by AT&T and perhaps other wireline carriers

The implementation procedures for the above three network plans differ considerably, but the implementation features of each will be described here. While the regional wireless plan is the primary plan for providing universal geographic coverage in the Region, the other two plan initiatives are proceeding forward and must be recognized as key elements in the regional comprehensive broadband telecommunications system.

County Level Public/Private Communications Network Plan Implementation – Regional Wireless Plan

The new 4.9 GHz public safety broadband communications network is an integral part of the regional wireless plan. A major advantage of the regional wireless plan is its public safety network component and the prospect of infrastructure cost sharing with a compatible commercial 5.8 GHz WiFiA broadband wireless network. Public safety communications can also be compatible with community-based wireless networks operating in a different frequency band. If the public safety and the commercial networks are to be jointly developed, however, a decision must be made early in the planning process to assure coordination of the planning and deployment of the two networks.

Since there is no regional government structure in Southeastern Wisconsin for telecommunication system plan implementation, such implementation must take place on a county-by-county basis. The seven county governments are, therefore, the key to regional wireless plan implementation. Plan implementation by individual counties, or groups of counties, would consist of the following sequence of steps:

1. Following endorsement of the recommended regional plan, an interested county government, or group of county governments, approve initiation of a 4.9 GHz/5.8 GHz wireless plan implementation project. That initiation approval would include a request to the Regional Planning Commission, or to a consultant, to prepare a more detailed, second level system plan, for the area designated in the request;

2. Review and approval of the preliminary second level system plan by the county or counties concerned. The preliminary system plan should provide for a joint 4.9/5.8 GHz public safety/commercial network that defines the system infrastructure, its estimated performance, and its capital and operating costs;

3. Conduct of field tests to verify or modify the preliminary second level plan as may be

found necessary. A randomized test location selection will provide for the necessary plan test at a reasonable cost. For public safety communications, testing with mobile vehicles as well as fixed locations will be required.

4. Review and approval of the revised second level system plan by the county or counties concerned; and approval of a budget for partial or full-scale deployment of the proposed broadband public safety network;

5. Issuance of a request for proposals to deploy the proposed infrastructure required for the 4.9 GHz public safety network in accordance with the approved plan; and selection of an infrastructure development vendor. Network infrastructure deployment must be supported by an equipment operation and maintenance training program for county law enforcement, fire, EMS and public works staff.

6. From this point in the implementation process, the commercial WiFiA network will follow a different path than the public safety network. In the public safety network, the county government is the owner and operator of the network. In a commercial network, the government typically plays a facilitator role. The next step in implementing the commercial element of the network would be the issuance of a request for proposals to deploy the required infrastructure in accordance with the approved plan.

   The deployment of this 5.8 GHz infrastructure would use common base stations with the public safety network, but would be an independent endeavor from the public safety wireless deployment. Substantial gains in efficiency may be expected from coordinating the two deployments.

   A firm commitment for county-wide deployment by the commercial service infrastructure contractor will be an important aspect of the regional wireless plan implementation. Restricting deployment to only areas with higher population densities would defeat a major objective of the plan.

   A major problem encountered by many communities interested in deploying broadband wireless networks has been finding a financially viable and stable means for operation and maintenance of the desired wireless networks. For a county-wide commercial component of a regional wireless network, this problem may be aggravated by the size and deployment cost of the network. For this reason, alternative means of financing and maintaining a commercial county-wide wireless network must be evaluated. One alternative, if no acceptable private infrastructure contractors can be found, involves the establishment of a special nonprofit economic development corporation to finance, deploy and maintain the wireless network infrastructure. The details related to the establishment of such a corporation are beyond the scope of this report. Detailed procedures for the launch of such an initiative are available based on similar organizations in other parts of the United States.

7. Issuance of a request for proposals to operate the system and selection of an Internet Service Provider (ISP) to operate the network.

   The proposals concerned should typically represent a simple procedure, since there are a significant number of internet service providers operating in the Region. If a separate organizational entity is available to deploy and maintain the commercial wireless network, a number of independent service providers should be well qualified to operate in a broadband wireless environment. A decision will be required by the county or counties concerned relating to whether one or multiple ISPs will be allowed to operate on the county network.

8. System operation

   There are at least two separate functions involved in system operation.

   a. Network management monitoring and maintenance (M^3); and

   b. Internet service provider operation (ISP)

The network M^3 function involves maintaining the integrity of the network by monitoring network traffic and performing actions as required to detect and repair equipment failures and supply sufficient capacity to insure a specified quality of service. ISP operation includes providing web, e-mail and other services along with marketing, sales, help desk and back office functions for customer billing and collections.

Wireless Communications Systems Business Model

The ultimate economic viability of any business depends on the validity of its business model. The wireless communications service business is no exception. The business environment for municipal and rural broadband wireless networks is currently clouded by the difficult startup experiences of municipal WiFi mesh networks. These networks have been plagued by sub-standard performance, unreliability, and subsequent loss of subscriber interest. The performance issue is a critical competitive factor.

Market surveys indicate that wireless network performance must exceed current DSL and cable broadband services in order to attract user interest. Municipal wireless mesh networks now operating in many cities throughout the United States are generally struggling financially with high infrastructure costs and too few users. Unless new wireless services are able to offer superior performance, market interest lags. Municipal wireless mesh networks now are limited to throughput of from 1 to 2 megabits per second, with inconsistent network reliability. The sectoral cellular wireless networks that are integral to both the regional wireless and the community-based wireless networks offer significantly lower infrastructure costs and throughput performance in the 15 to 20 megabits per second range. WiFi mesh network deployment costs range from $100,000 to $250,000 per square mile, with full coverage closer to the latter figure[1]. By contrast, the infrastructure costs for community-based wireless networks employing the sectoral cellular network topology are currently costing about $2,500 per square mile in rural areas such as the Town of Wayne[2] and about $14,000 per square mile in urban areas such as the City of Waukesha[3]. These infrastructure costs cover all of the access point equipment, the network monitoring system, the Internet gateway connection and initial engineering support, but does not include the server computer equipment of the Internet Service Provider (ISP) which is not part of the network itself. Since there may be multiple ISPs on a given wireless network, these costs are not really part of the network infrastructure. These low infrastructure costs in conjunction with the enhanced throughput performance provide the foundation for a sound business model.

Community Level Network Plan Implementation

Plan implementation by individual municipalities or groups of municipalities would consist of the following sequence of steps:

1. Following adoption or endorsement of the recommended regional plan, the interested municipality, or group of municipalities, would request the Commission, or a consultant, to prepare a second level, more detailed plan for the area designated in the request;

2. Review and approval of the preliminary system plan by the municipalities comprising each service area concerned;

3. Conduct of field tests to verify or modify the preliminary plan as may be found necessary, a randomized test location selection will provide the necessary plan at a reasonable cost;

[1] *Daggett, B. V. "Dollars and Sense on Muni Wireless"*, Government Finance Review, *February, 2007.*

[2] *Broadband Wireless Field Test Report, Town of Wayne, Washington County, Wisconsin, SEWRPC, October 16, 2006.*

[3] *Broadband WiFi Wireless Telecommunications Planning Proposal, City of Waukesha, Wisconsin, SEWRPC, October, 2006.*

4. Review and approval of the revised second level system plan by the municipalities concerned, and approval of a budget for partial, or full scale deployment of the proposed system;

5. Issuance of a request for proposals to deploy the proposed infrastructure in accordance with the approved plan; and selection of an infrastructure development vendor. Network infrastructure deployment must be supported by an equipment operation and maintenance training program for designated municipal staff;

6. Issuance of a request for proposals to operate the system, and selection of an Internet service provider to operate the system; and

7. System operation.

Plan preparation using radio propagation modeling and design optimization model tools would take place as previously described in Chapter VII, and would be initiated by the Commission or a consultant upon request of the community. Each community level wireless plan would then be presented to the appropriate local governing body and advisory committees to that body for review and approval. Upon approval, the community would submit a letter requesting the Commission or a consultant to move to step 3—field study verification of the community wireless plan.

Field study plan verification involves an extensive series of radio frequency signal intensity measurements using temporarily located access point equipment, equivalent to that planned for use in the network infrastructure. A truck-mounted antenna mast is employed for a series of temporary access point locations. For each temporary access point location, a signal-level coverage map is prepared based on a large number of radio frequency signal level measurements collected in a moving vehicle equipped with a WiFi-enabled laptop computer with a professional site survey software package. A variety of network performance measures will be recorded including signal level, noise level, throughput (packet speed), and packet retry and loss rates. In small networks with a few access points as in rural areas, all of the access points can be covered and performance verified. In larger networks, a randomly selected set of access points can be used to statistically verify network coverage and performance. The field survey will identify weak coverage or performance areas which may require additional or relocated access points to achieve network coverage and performance objectives.

Following the completion of the field survey studies, the adjusted plan is resubmitted to the community for final review and approval. Upon approval, the plan implementation process would move to the final five stages which involve various aspects of vendor selection and system startup. The manner in which these final stages are approached depends on the general business model selected. If private service providers are asked and respond to a formal request for proposal, then steps 5 through 8 would be accomplished as a continuous final single stage process. If an alternative government ownership model is chosen, then infrastructure deployment and ISP (Internet Service Provider) selection would be executed as a two-stage process.

Whether the private or public version of a business model is selected, this business model plan must detail the marketing, training, financial and general business aspects of the proposed network operation in order to generate confidence in the economic viability of the new venture in a competitive environment.

Operational management of the new wireless system would be based on a network management system that employs real-time network monitoring to measure network performance in order to provide information for rapid trouble-shooting of network outages, and early identification and correction of network bottlenecks or areas of weak signal coverage.

The end result of the community-based WiFi network plan implementation process would be an operating broadband wireless network system that achieves the agreed upon performance objectives and is able to grow and adapt to an expanding network clientele. A wireless communications network system can be well managed only through constant observation of its dynamic nature as it grows its user base and adapts to changing traffic patterns.

Private Service Provider Plan Implementation

In addition to implementation of the primary regional wireless plan and the supporting community-based wireless plan, other wireline and wireless service providers will be deploying advanced networks designed to enhance the broadband telecommunications capabilities of Southeastern Wisconsin.

In the wireline arena, AT&T is rapidly deploying its U-Verse Network (Project Lightspeed) in selected communities within the Region. A list of the communities within the Region with AT&T agreements governing the deployment could be obtained by inquiries to communities. Even such a list, however, would not necessarily accurately define the geographic coverage of the FTTN network since AT&T is under no obligation to serve all geographic areas of a given community. U-Verse is a downstream-oriented communications technology. The emphasis is on television service, particularly high definition and interactive video which requires significant downstream bandwidth capacity. Internet upstream data throughput is limited to 1 megabit per second, while downstream throughput is limited to 7 megabits per second. These parameters, originally covered extensively in Chapter VII, are repeated here only to provide a better understanding of the nature of the U-Verse market and its impact on overall regional plan implementation.

Given the performance parameters of U-Verse, there is no inherent conflict envisioned between the parallel deployment of AT&T's U-Verse network and the regional and community-based wireless networks. U-Verse's primary objective is to compete with the cable companies in providing a combination of television, telephone, and Internet data services. The primary objective of the regional wireless network is to provide fourth generation (4G) symmetric broadband Internet data services throughout the entire Southeastern Wisconsin Region. Voice communications services through the Internet (VoIP) will also be available if the demand emerges. A major subsidiary objective of the regional wireless network is a robust telecommunications network for public safety, a network capable of functioning in a major public emergency. Since the commercial element (5.8 GHz) of the regional wireless network will share a common base station layout, these same robust features could also be built into the regional 5.8 GHz network.

The implementation of community-based wireless networks has similar objectives as the regional plan, albeit at a more local level. The objectives of these community networks may vary greatly depending on the location and characteristics of the community. Rural townships within the Region such as Wayne in Washington County generally have no broadband services at all. For these communities, a community-based wireless network is practically the only opportunity to cross over the digital divide and achieve 4G-level broadband performance.

Suburban communities within the Region, such as Hartland, Thiensville or the North Shore suburbs, are in a different competitive situation. Broadband communications in the form of cable, telephone DSL or the new AT&T U-Verse networks are, or generally will be, available to all residents and businesses. Except for the new U-Verse network, broadband services from these providers is generally in the 1.5 to 2.5 megabits per second range. Upstream data rates are in the under 500 kilobits per seconds range (0.5 megabits per second). U-Verse, aside from television services, offers upgrades to 7 megabits per second downstream, and 1 megabit per second upstream. The driving force in these communities for advanced broadband communications will be from individuals and organizations whose needs are better satisfied by high speed symmetrical data and video transmission. An example of such an application is video conferencing. High quality video conferencing requires significant data transmission rates not satisfied by current cable, DSL or U-Verse offerings. Business conferencing and medical monitoring in home healthcare, are two examples of potential videoconferencing applications. Such applications along with data intensive small business firms may be expected to comprise the primary justification for the provision of 4G broadband and community based wireless in the coming years.

Cellular Wireless Service Providers

A major class of regional private service providers are the cellular wireless companies: AT&T, Verizon Wireless, Sprint/Nextel, U.S. Cellular and T-Mobile. All five service providers have extensive wireless networks in the Region. Only one of these five, Sprint/Nextel, has committed publicly to a 4G-level technology, WiMAX, for planned deployment in the United States, although not yet in the seven-county region. Some other service providers and communications equipment manufacturers are supporting another evolving technology called Long-Term Evolution (LTE). LTE represents an attempt by the manufacturers and wireless service providers to regain the initiative for proprietary wireless communications technologies. Having lost the performance initiative to IEEE Standard Technologies such as WiFi and WiMAX, LTE tries to find a future broadband role for the current proprietary

GSM/UMTS and CDMA technologies. LTE Standards are scheduled to be finalized by the end of 2007. First commercial applications are scheduled to take place in late 2009 or early 2010. Throughput performance exceeding 100 megabits per second is promised. The infrastructure costs of LTE proprietary technologies may be expected to exceed significantly those of IEEE standards. Whether such higher cost technologies can compete with technologies based upon IEEE Standards is still to be demonstrated.

The future of WiMAX as a broadband mobile wireless technology is still uncertain. Originally conceived as an IEEE standards replacement technology for WiFi, WiMAX has currently emphasized use by the private wireless service providers. All of the early releases of WiMAX (802.16e) are in the licensed frequency bands such as 2.5 GHz and 3.5 GHz. These bands are available only to major wireless service providers. At the same time, the early releases of WiMAX seem compromised in throughput performance. Early range targets of 30 to 40 miles have been replaced with 0.5 to 1.0 mile maxima. At these ranges, the WiMAX mobile wireless plan is not competitive and the only alternative for mobile broadband wireless in the Region, at least in the near future, is advanced Mobile WiFi.

SUMMARY

Plan implementation strategies and procedures are outlined in this chapter for both private service providers and public agencies. Public agencies must first approve the plan in a formal plan endorsement process. The regional wireless plan would require endorsement by each of the seven counties prior to implementation in the respective county areas. Community-based wireless plans would require endorsement by the individual local units of government.

Recommended plan implementation strategies and procedures are detailed in this chapter for the regional wireless plan and the Community-based wireless plan. Potential plan implementation strategies and procedures for private service providers in the Region are reviewed and explained.

Regional Wireless Plan implementation at the county level first requires approval of a project that will initiate a planning, field testing and eventual deployment of a broadband public safety network within the county. The initial phases of the project involve network plan preparation and field testing to verify the plan. After the verified plan is approved, the county must provide budget authorization for the deployment of the 4.9 GHz public safety communications portion of the county-based regional wireless plan. Deployment of the public safety network can then move forward in a county-wide application.

Implementing the commercial wireless portion of the Regional Wireless Plan follows a similar path to the public safety network in the early planning and testing phases, but the path of implementation changes in final system deployment. It must be reemphasized here that a central strength of the Regional Wireless Plan is this public-private partnership. This partnership not only supports a major advancement in public safety communications, but it also improves the business model for service to low population density geographic areas throughout the Region that otherwise would go unserved. In light of the recent adverse publicity relating to the viability of WiFi business model, this cost sharing partnership feature is a strong reason for the universal endorsement of the regional wireless plan. Universal geographic coverage has been ranked as second only to performance as a primary objective of this regional telecommunication planning process. A serious effort to accomplish this objective requires implementation of the regional wireless plan.

Implementation of community-based wireless plans face more complex issues. Deployment in rural towns will differ greatly from deployment in urban and suburban areas of the Region. Rural towns currently have little or no broadband telecommunications services and may be expected to be eager to cooperate with any broadband service that can close the digital divide. Urban and suburban areas already have competing cable and telephone line-based broadband communications services. Implementation in such areas will require a more competitive business model with emphasis on service differentiation. Successful community-based wireless networks will require marketing emphasis on performance features that distinguish them from cable or DSL broadband services. Successful community-based wireless networks will also require the selection of a financially-sound and technically capable service provider. Recent experience indicates a shortage of such organizations, and it may be necessary to divide the responsibility between two organizations – one to finance, deploy and maintain the network infrastructure, and a second, the Internet Service Provider, to operate the system as a business.

Finally, private service providers such as AT&T and the wireless service providers have their own implementation plans. To the extent that these plans improve broadband telecommunications in the Region, they are supportive of regional telecommunications plan objectives. Unfortunately, none of these private plans, wireline or wireless, announced to date, meets all of the objectives set forth in Chapter III of this report. AT&T's U-Verse network complies with downstream throughput objectives, but only for television services, not for general Internet usage. Its upstream throughput performance and geographic coverage are far below established 4G standards.

Neither the wireline cable service provider nor the cellular wireless carriers have released any 4G level plans as of this writing.

Chapter X

SUMMARY

This planning report documents the findings and recommendations of the planning process conducted by the Southeastern Wisconsin Regional Planning Commission to develop a comprehensive telecommunications system plan for the seven-county Southeastern Wisconsin Region. The planning process concerned was initiated in August 2004. The wireless telecommunications element of the planning process was completed in May 2006, and the findings and recommendations are set forth in SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin*. The plan presented in this report integrates wireless and wireline communications technologies into a comprehensive regional plan for a telecommunications network. The findings and recommendations are presented in the nine chapters which together with this summary comprise the report.

The planning program was directed by a Telecommunications Planning Advisory Committee. This Committee was created by the Commission to assist in the preparation of a regional telecommunications plan for the seven-county Southeastern Wisconsin Region. The Committee was comprised of 21 members chosen by the Commission on the basis of their knowledge and experience in telecommunications and in comprehensive planning. The membership of the Committee is listed on the inside front cover of this report. The Committee met 21 times during the course of the planning effort, to review, revise as found to be necessary, and approve the draft chapters of this report. Minutes of the Committee deliberations are on file in the Commission offices.

Chapter I presents background information about the Regional Planning Commission, the regional planning concept in Southeastern Wisconsin, and about the seven-county planning Region; including basic information on the size, resident population, employment, real property valuation, and governmental structure of the Region. The Chapter also contains a brief description of the work programs undertaken by the Commission from its creation in 1960 through 2004. Importantly, the Chapter describes the importance of telecommunications to the continued sound social and economic development of the Region, and the need for regional telecommunications planning. The Chapter notes that the regional telecommunications planning effort was being conducted in accordance with a Prospectus adopted by the Commission in December 2003. This Prospectus envisioned the regional telecommunications plan to be comprised of two principal elements: a broadband wireless communications plan, and a comprehensive telecommunications network plan that considered both wireless and wireline technologies.

Chapter II sets forth the basic principles and concepts underlying the regional telecommunications planning process; describes that process; and, importantly, describes the technologies involved, including wireless and wireline networks.

Chapter III sets forth a set of eight objectives that should be met by the regional telecommunications system, together with their supporting principles and standards. These objectives relate to system performance, as measured by data transmission rate, availability, quality of voice transmission, error rate, and packet loss; universality of service; redundancy; antenna site number optimization; application to be served; cost minimization; antenna site aesthetics and safety; and use in public safety emergencies. The objectives and supporting quantitative standards were intended to be used in plan design and evaluation of alternative plans and the selection of a recommended plan.

Chapter IV presents inventory findings relating to pertinent background conditions within the Region including information on the demographic and economic base, land use pattern, and supporting transportation facilities and services.

Chapter V presents the geographic coverage areas and broadband communications service offerings of wireline and wireless service providers in the Region. The dominant broadband service providers are the incumbent telephone service providers, AT&T, Century Tel and Verizon North, along with the cable companies, Time Warner Cable and Charter Communications. The inventories conducted under the planning program indicate that none of these service providers currently provide the fourth generation (4G) level of performance called for in the objectives and standards specified in Chapter III of this report. None of the existing wireline or wireless services also offer the universal regional geographic coverage recommended in the Commission's fourth generation (4G) standards. AT&T's current deployment of Project Lightspeed will offer download throughput speeds at 4G standards, but upload transmissions of 1 megabit per second will be below 4G specifications. This new fiber-to-the-node network deployment also will not provide universal geographic coverage within the Region.

Chapter VI documents the current performance of existing broadband wireline and wireless communications technologies based on data collected at the national, state and regional levels. Telephone line-based DSL and hybrid fiber-coax cable broadband services are emphasized since these technologies and companies control about 98 percent of the broadband services communications services market. Throughput performance for both DSL and cable services is in the 1 to 3 megabits per second range, below the specified 4G standards. Upload speeds are well below 500 kilobits per second for both DSL and cable as well as for most broadband wireless services. In addition to national and state-level aggregate performance information, performance ratings are also graphically presented for both major and smaller wireline and wireless carriers.

Chapter VII describes the alternative broadband wireless and wireline communications technologies and regional plans for Southeastern Wisconsin. Technology reviews emphasize broadband wireline fiber optic technologies since wireless technologies were extensively covered in SEWRPC Planning Report No. 51. Particular interest was directed to Fiber-to-the-Node (FTTN) and Fiber-to the-Premises (FTTP) technologies. FTTN technology involves the deployment of fiber optic links to remote locations that then connect with subscribes through existing copper wiring. Each node is able to serve users within a radius of 3,000 feet with high speed video and data services. Download throughput, however, is emphasized, with rates up to 25 megabits per second. Upstream transmission in contrast is limited to 1 megabit per second. Fiber-to-the-Premises technology represents the greatest throughput potential even though the particular passive form now being deployed has serious limitations compared to the active form which is significantly more expensive both initially and in operating costs.

One new wireless technology, mobile WiMAX, which was not considered in SEWRPC Planning Report No. 51, is considered in this report. Mobile WiMAX – as defined by IEEE Standard 802.16e – is the mobile cellular version of WiMAX in which the user employs a WiMAX cellphone. The technology, unlike fixed WiMAX and WiFi, is restricted to large service providers who have purchased licensed spectrum from the Federal FCC. It is a technology with great potential to comply with the plan objectives set forth herein, but in its initially released form it requires an excessively large number of base stations and is not cost effective for universal geographic coverage in the Region.

The majority of Chapter VII is devoted to descriptions of four alternative primary, and two alternative adjunct, regional broadband communications plans. These alternative primary plans included: 1. A Community-Based Wireless Plan; 2. Regional Wireless Plan; 3. Fiber-to-the-Node Wireline Plan; and 4. Fiber-to-the Premises Wireline Plan.

The two alternative adjunct plans provided for mobile cellphone wireless communications in support of the primary plans that emphasized fixed users. The two adjunct plans included: 1. Mobile WiMAX-Based Wireless Plan, and 2. Mobile WiFi-based Wireless Plan.

All of the primary and adjunct plans were presented in terms of their technical characteristics, geographic coverage, cost and other features to provide the basis for quantitative evaluation and plan selection in Chapter VIII. The only alternative plan which meets the objective of full regional geographic coverage is the regional wireless plan. Geographic coverage of the other plans depends upon the individual decisions of either private service providers or local government officials. The regional wireless plan also provides the lowest infrastructure cost even without considering the cost sharing benefits of common base station sites with public safety communications networks. The regional wireless plan includes explicit provisions for public safety communications in the 4.9 GHz band which may be expected to become the preferred system in broadband wireless public safety communications.

All of the four primary alternative plans, two wireline and two wireless, comply with the basic throughput standard of 20 megabits per second, but the fiber-to-the-premises (FTTP) offers potentially higher performance in future years extending up into the gigabits per second range. The Fiber-to-the Node Plan alternative currently being deployed by AT&T in the Region in Project Lightspeed has more limited throughput performance growth potential based on the bandwidth limitations of the final copper link connection. New developments in wireless communications such as multiple input - multiple output (MIMO) are standardized in the IEEE standard 802.11n which deals with advanced multiple antenna WiFi. Table 20 in Chapter VII provides an abbreviated but comprehensive summary of the four alternative primary and two alternative adjunct plans considered.

The adjunct plans relate to mobile wireless communications. Mobile cellular networks in the United States have developed as semi-independent entities serving mobile users primarily in voice communications. Data services were initiated in second generation (2G) networks and enhanced for faster data transmission recently in 3G networks. The primary focus of this planning effort was higher throughput networks providing the same performance as fixed user networks. Such improved performance is important since mobile wireless networks have become the primary means of communication for a growing part of the regional population. Many users, particularly younger users, communicate exclusively by mobile and have no fixed service in their place of residence.

The first released versions of WiMAX have limited range as mobile networks and are costlier than their WiFi counterparts which can operate as auxiliary networks to the regional wireless and community-based wireless networks. The lower costs of WiFi equipment and its ability to operate jointly with fixed wireless networks contributed to its choice for the broadband mobile wireless plan.

Chapter VIII documents the plan evaluation and selection process involved in selecting a final regional comprehensive broadband telecommunications plan. The rank-based expected value method is presented as the basis for plan evaluation and selection. The method involves a priority ranking first of the applicable objectives and standards followed by a ranking of each plan under each standard. These dual rankings are then used to determine the value of each plan. The plan value combined with the probability of plan implementation determine the expected values of the various plans. The plan with the highest expected value is then selected as the preferred plan. The primary alternative plans received rank-based expected values as follows:

1. Regional Wireless Plan – V = 39.0

2. FTTN Wireline Plan – V= 39.2

3. Community-Based Wireless Plan – V = 31.2

4. FTTP Wireline Plan – V = 12.6

The rank-based expected value method produces a virtual tie between the Regional Wireless Plan and the FTTN Wireline Plan, but the Regional Wireless Plan was selected as the preferred plan based on public-private cost sharing of the regional wireless plan and its commitment to provide universal geographic coverage in the Region.

The adjunct mobile wireless plans received expected value scores of:

1. WiMAX Mobile Wireless Plan – V = 8.1

2. WiFi Mobile Wireless Plan – V = 21.6

Based on the evaluation scores, the regional wireless plan and the WiFi mobile wireless plan were selected as the recommended regional comprehensive broadband telecommunications plan for Southeastern Wisconsin.

Chapter IX sets forth an approach to the implementation of the regional wireless plan and its associated WiFi mobile wireless plan together with provision for other broadband wireline and wireless networks already being deployed in the Region. Telecommunications plans involving public agencies, particularly those including public safety communications networks, require a formal adoption process. Deployment of the regional wireless plan will require regional plan endorsement and subsequent implementation at the County-level of government. Community-based wireless plans are adopted and implemented by municipal units of government.

A central feature of the selected regional wireless plan is the potential for cooperative effort by the public and private sectors in which the infrastructure costs are shared between the public safety and commercial networks. The public safety telecommunications networks are envisioned to be implemented at the county or multi-county level, providing an opportunity for cooperation between the counties and private sector providers.

Community-based wireless networks are implemented on a community-by-community basis with significant differences depending on the location and nature of the community. Low density rural communities such as towns are generally easier to serve than urbanized communities due to their pressing need for broadband communications services. Urbanized communities usually have broadband communications in the form of hybrid fiber-coax cable and telephone-network based DSL. Such communities must be persuaded of the advantages of new higher speed networks in comparison with existing broadband networks.

The only declared 4G-level private service provider initiative in Southeastern Wisconsin is AT&T's Project Lightspeed also called U-Verse. Its primary target however, is the television entertainment market rather than regional economic development as evidenced by the majority of bandwidth being devoted to broadcast television. Neither downstream (7 megabits per second) nor upstream (1 megabit per second) data rates comply with the 4G objectives and standards established in Chapter III of this planning document.

Neither of the regional two cable service companies nor the five mobile wireless cellular service providers have announced any fourth generation broadband communications initiatives at the time this planning report was completed.

APPENDICES

Appendix A

ENVIRONMENTAL IMPACT ASSESSMENT OF THE REGIONAL BROADBAND WIRELESS SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN

Introduction
It has been the long-standing policy of the Southeastern Wisconsin Regional Planning Commission to perform an environmental assessment of its recommended plans, and to include the findings of such assessments in the planning reports which set forth the Commission recommended plans. Accordingly, this Appendix sets forth the findings of an environmental assessment of the Commission's recommended wireless telecommunications plan for Southeastern Wisconsin.

The environmental assessment focuses on the potential effects on human health of radio frequency transmissions, considering to the extent possible given the current state of the art of both the thermal and athermal effect of such transmissions. The assessment does not concern itself with the potential impacts of the location of transmitting and receiving structures on surrounding land uses and on property values. Such impacts are highly site specific and can only be properly considered in the preliminary engineering stage of plan implementation when specific station locations together with their surrounding environments have been identified.

Background Information
Wireless communications systems are usually based on transfers of radio frequency electromagnetic energy between users with antenna base stations or network access points as intermediaries. Some wireless networks such as amateur radio and citizen band radio also allow for direct communications between users without the need for base station or access point intermediaries. The radio frequency signals used in these wireless networks are typically of low power, with transmitting powers ranging from about 100 milliwatts to as high as 1,000 watts. To put these power levels in perspective, most commercial AM radio broadcasting stations transmit at power levels of 50,000 watts. The Voice of America broadcasts at power levels of 500 kilowatts, with directional power levels as high as 100 megawatts. The typical cellular wireless network base station transmits at about 150 watts, far below the levels of radio and television broadcasting stations, and also far below the levels of shortwave radio broadcasting stations and many amateur radio stations.

Whatever the power level, the function of wireless radiowave communications is to convey information, not to transfer power or energy. Whether the media is voice, data, or video, radio frequency signal performance is based on the transfer rate of information and not the watts of power. To transfer information, however, an adequate level of radio frequency power is required, the power required depending on the frequency of the signal transmitted, the distance, the nature of the propagation path traversed, and the sensitivity of the receiver processing these signals. Although the primary function in telecommunications is information transfer, various levels of radio frequency power may have secondary effects. These secondary effects may affect the health of persons in the path of radio frequency radiation. The purpose of this assessment is to evaluate the potential health effects of radio frequency radiation created by wireless telecommunications networks particularly those existing and proposed networks comprising a part of the broadband wireless telecommunications system plan for Southeastern Wisconsin.

The two types of radio frequency health effects to be examined are thermal effects and athermal effects. The thermal effects of radio frequency energy on the human body are fairly well understood, and maximum permissible exposure limits as a function of frequency are specified by the Federal Communications Commission (FCC). Wireless telecommunications networks are prohibited by law from violating these exposure limits in their network operations. Athermal effects, in contrast, are not well understood, and are currently very controversial with conflicting results from controlled laboratory and epidemiological studies.

The findings of this assessment of potential environmental impacts indicate that the FCC maximum permissible exposure limits for radio frequency thermal exposure are not being violated by cellular/PCS or other wireless systems currently deployed within the Region. The Commission planned broadband WiFi/WiMAX based systems with their very low transmitting power are even farther below these thermal exposure limits, and pose no thermal health hazards for citizens of Southeastern Wisconsin.

Athermal effects present a more ambiguous picture with conflicting results in different controlled studies. A recent major study sponsored by the European Union (EU 2004), which aggregated the results of many RF-EMF (radio frequency electromagnetic fields) studies, did indicate that there were valid concerns about athermal effects on human DNA strands and various body tissues at lower than published FCC thermal effect exposure levels. These studies, all based on *in vitro* laboratory investigations, however, were not directly related to human health effects; and, therefore, were not considered conclusive with respect to use in establishing new maximum permissible exposure (MPE) limits for athermal radio frequency radiation.

Given the uncertainty of radio frequency radiation athermal health effects, prudence would require that a low power telecommunications approach be used in the preparation of Commission broadband wireless communications plans. Radio frequency radiation effects, whether thermal or athermal, are a function of radio frequency power density. Low power telecommunications facilities may be defined as facilities with transmitting powers limited to a maximum power of 5 watts. Use of such relatively low power requires significantly increased receiver sensitivities to compensate for reduced transmitting power. Such enhanced receiver sensitivities, are well within the current state of telecommunications technologies. Use of low power transmitters not only reduces the risks of radio frequency exposure, but also provides an improved radio frequency environment. Radio frequency interference (RFI) has become one of the major obstacles to wireless telecommunications, and universal adaptation of low power standards would do much to alleviate this obstacle. Environmentally, low power transmission also allows for the use of solar panels on access points, taking wireless off the electric power grid for more reliable and environmentally-friendly telecommunications.

Radio Frequency Radiation

Radio frequency (RF) radiation, for the purposes of this study is defined as radiation in the spectral range of 50 MHz to 18 GHz. Such a frequency range encompasses all known current commercial and public wireless communications networks. Most existing and planned commercial and public wireless networks are, and may be expected to remain in the 800 MHz to 6 GHz range. The only major exceptions are satellite broadband transmissions which operate in the 12 to 18 GHz band. Some public safety telecommunications networks still operate in the 50 or 150 MHz bands.

Radio frequency radiation is classified as a non-ionizing form of radiation in contrast with x-rays, gamma rays, and even some ultra-violet fields which are designated as ionizing radiation. Ionizing radiators have enough energy to dislodge electrons from their atoms. When this happens, positive and negative ions are formed with well-documented potential damage to human health. At sufficiently high power densities, however, radio frequency radiation can pose health hazards. Experience since the early days of radio has shown that radio frequency energy can cause injury by heating body tissue. Radio frequency burns can be extremely painful, but even lower level tissue heating can be damaging to internal body organs. Radio frequency induced heating of the eye can result in cataracts or even cause blindness. These heat-related hazards of radio frequency radiation are called thermal effects.

Extensive research has also been conducted on changes in physiological function in the presence of radio frequency energy that is too low to cause heating. These athermal effects are more subtle than thermal heating and involve changes in function at the cellular level that may produce breakages in DNA strands. The conflicting results of laboratory studies relating to this concern make it difficult to establish exposure guidelines. The alternative approach is to adopt a policy requiring low power telecommunications.

Thermal Effects of Radio Frequency Energy

Body tissues exposed to very high levels of radio frequency energy may suffer serious heat damage.[1] These effects depend upon the frequency of the energy, and the power density of the radio frequency field striking the body, together with other factors such as the polarization of the radio wave.

Radio frequency energy is absorbed more efficiently at frequencies near the body's natural frequency which is about 35 MHz for a grounded person, and 70 MHz for a person insulated from ground. Various parts of the body have different resonant frequencies such as the adult head of about 400 MHz and the infant head of about 700 MHz. As the frequency moves away from body resonance, less radio frequency heating is experienced. The specific absorption rate, (SAR) defines the rate at which radio frequency energy is absorbed in tissue.

[1] *Hare E.* Radio Frequency Exposure and You, *American Radio Relay League, 2003-Chapter 3.*

Based on power density levels specified by the IEEE/FCC in the latest releases, there is no evidence to support a conclusion that existing or planned wireless base stations, or access points, exceed the thermal radio frequency exposure limits. On October 3, 2005, the Standards board of the IEEE Standards Association approved a new "Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz"[2,3] The maximum permissible exposure standard for the frequency range of interest is between 2 watts per square meter and 10 watts per square meter in the band from 400 to 2000 MHz, and 10 watts per square meter for frequencies above 2000 MHz.

Three particular frequencies of interest related to existing cellular/PCS or planned WiFi/WiMAX networks are:

Cellular – 800 to 900 MHz
PCS – 1900 MHz
WiFi/WiMAX – 2.4 to 5.8 GHz

The maximum permissible exposure (MPE) for these three frequency bands are:

800-900 MHz: 4.0 to 4.5 W/m^2
1900 MHz: 9.5 W/m^2
2.4 to 5.8 GHz: 10.0 W/m^2

The above MPEs are all for so-called "uncontrolled environments" in which the people involved are unaware of radio frequency radiation. Such limits generally are about 20 percent of the limits for controlled environments where technical personnel are aware of radio frequency radiation.

[2] *Lin, James,* A New Standards for Safety Levels with Respect to Human Exposure to Radio Frequency Radiation *IEEE Antennas and Propagation Magazine, 48, 1, February 2006.*

[3] *IEEE International Committee on Electromagnetic Safety (SCC39), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE Std C95.1TM-2005 (Revision of IEEE Std C95.1-1991).*

The formula for radio frequency power flux density in free space is:

$S = p_t/4\pi r^2$
Where
S – power flux density – watts per square meter
p_t – transmit power – kilowatts
r – distance – kilometers

Using logarithmic ratios and practical units:

$S = -41 + P_t - 20 \log d$
Where
S – power flux density in dBW – decibels relative to watt per square meter
P_t –power dBKW decibels relative to 1 kilowatt
d – distance – kilometers

The above formula represents radio propagation in free space. In terrestrial application, the presence of natural foliage and structural interferences will attenuate the radio signal below free space levels. Therefore, free space presents a worst case scenario.

Based on the above formula, a typical 100 watt cellular transmitter in the 800 MHz frequency band produces a power density of 0.00079 watts per square meter at 100 meters from the site and 0.079 watts per square meter at 10 meters from the site. The largest regional cellular transmitter radiating at 1,000 watts would result in 0.0079 watts per square meter at 100 meters, and 0.79 watts per square meter at 10 meters from the site. A low power—4 watt—WiFi transmitter creates power densities of only 0.0003 watts per square meter at 100 meters from an access point and 0.003 watts per square meter at 10 meters from the access point.

From the above, it is apparent that none of the three classes of wireless radio frequency radiation violate the latest IEEE/FCC MPE limits. These limits are based upon thermal effects testing involving heating tissue with radiation of 2 watts per kilogram of body weight. Although none of the above examples violate the latest IEEE/FCC MPE restrictions; the 1,000 watt transmitter at 800 MHz does approach the limit—0.79 watts per square meter versus 4.00 watts per square meter—and the question of cumulative effects arises. The averaging time used to determine the above MPE standards is 30 minutes; the radio frequency temperature effects on human tissue and organs having been studied during 30 minute periods. Varying levels of radio frequency radiation were evaluated, and the level of radio frequency radiation that produced sustained temperature rise in human tissue was established. MPE limits were then set at 2 percent of these thresholds, providing a safety factor of 50 to one for uncontrolled environments. The MPE for controlled environments was set five times higher at 10 percent of the sustained temperature threshold.

The official IEEE/FCC position on cumulative effects is that such effects do not exist below the MPE limits. Restated, if the radio frequency radiation level is below the MPE limit for the frequency of interest, the exposure time whether continuous or intermittent is irrelevant. The rationale for this stated position is clear. If the radio frequency radiation level does not produce sustained heating of human tissue, then exposure time does not matter.

In summary, investigation of the potential thermal effects of radio frequency radiation on human health from wireless communications systems in Southeastern Wisconsin indicates that all current and planned systems should be operating within the latest IEEE/FCC standards. Since the investigation was based entirely on theoretical radio propagation in free space, it is important to confirm this analysis with propagation modeling and some field measurements.

Radio Propagation Modeling

Radio propagation modeling estimates radio frequency radiation levels in a given terrestrial environment. Such radiation levels will be lower in value than those estimated by the free space propagation power density formulas because of signal attenuation from buildings and terrestrial vegetation. To determine the effects of terrestrial attenuation on radio frequency radiation exposure, a series of radio propagation modeling plots were prepared for both cellular (800-900 MegaHertz) and WiFi/WiMAX (2400 MHz) frequency bands. Because available modeling software produced results only in terms of field strength, it was first necessary to convert the IEEE/FCC standard into field strengths limits. To utilize the standard FCC formula for field strength conversion set forth in FCC DET Bulletin 65, Edition 97-01, it is necessary to convert from watts per square meter to milliwatt per square centimeter.

By dimensional analysis:

10 watts per square meter = one milliwatt per square centimeter

The conversion formula in FCC Bulletin 65 states:

$E^2 = 3770S$

where E = electric field strength in volts per meter

and S = power density of one milliwatt per square centimeter

Solving

$E = 61.4$ volts per meter

$E = 61.4 \times 10^6$ microvolts per meter

$= 20 \log_{10} 61.4 \times 10^6$

$= 155.8$ decibels microvolts per meter (dB μV/m)

The lower two watts per square meter standard for the 800 MHz band is[4]

$E = 27.4$ volts per meter

$= 148.7$ dB μV/m

Observing the two radio propagation plots shown on Maps A-1 and A-2, the highest field strength category for a 100 watt, 891 MHz site is represented by the yellow colored area, representing a field strength of only one volt per meter, well below the 27.4 volts per meter standard. The highest field strength level predominant near the base station is indicated by the brown colored area which represents about 0.1 volt per meter–again well below the MPE standard.

In Map A-2, for a 4 watt WiFi access point, the highest field strength level is indicated by the purple colored area representing 75 dB μV/m which is three orders of magnitude below a field strength of about 0.001 to 0.002 volt per meter.

From the above field strength plots shown in Maps A-1 and A-2, it is clear that both the existing cellular/PCS base stations should operate well within the IEEE/FCC MPE standards. Future WiFi/WiMAX networks may be expected to be at least three orders of magnitude below these same standards.

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[4] *Barclay, Les,* Propagation of Radio Waves, *The Institution of Electrical Engineers, United Kingdom, 2003.*

The field strength plots shown on Maps A-1 and A-2 are based upon one transceiver-antenna unit mounted on a station structure. For multiple unit installations the radiation output will be a multiple of the transceiver-antenna units. The maximum number of co-located antennas in the Region was five. Even the power radiated by this collection of antennas would still be a very small percentage of the standard for the worst case in the 800 MHz band.

Field Testing

Thermal radiation effects based on free space formulas and radio propagation modeling were supplemented by field measurements taken with a Spectran HF spectrum analyzer instrument manufactured by Aaronica AG of Germany. Measurements were made of both a 55 watt, 1,932 MHz base station (Sprint) and a 4 watt, 2.4 GHz access point. The following power density and field strength levels were recorded.

1. 1,932 MHz base station at a distance of 300 feet from the base of the antenna tower
   S = 120.14 microwatts per square meter
   E = 0.213 volt per meter

2. 2.4 GHz access point at a distance of 300 feet from the base of the utility pole.
   S = 51.4 microwatts per square meter
   E =0.139 volts per meter

A comparison of the RF radiation standards compliance for thermal effect is summarized in Table A-1. It is apparent from the table that whether radio propagation formulas or field measurements are applied that both cellular/PCS and WiFi/ WiMAX networks are well below FCC/IEEE exposure standards.

Athermal Effects

Athermal effects of radio frequency radiation are caused by low-level energy fields insufficient to cause either ionization or heating effects. Research investigations in this area relating to possible health effects of radio frequency radiation exposure has been of two types: epidemiological research and laboratory research. Epidemiologists observe health patterns of large groups of people using statistical methods. These studies look for associations between environmental factors and an observed pattern of illness. Some epidemiological studies have shown an exposure to radio frequency radiation to be associated with malignancies such as leukemia and brain cancer. A large number of equally well designed and performed studies have shown no such association.

Laboratory studies of radio frequency radiation have a similar history. Some studies have indicated the ability of low levels of radio frequency radiation to alter the human body's circular rhythms and weaken the immune system. Attempts to replicate these studies have also had mixed results.

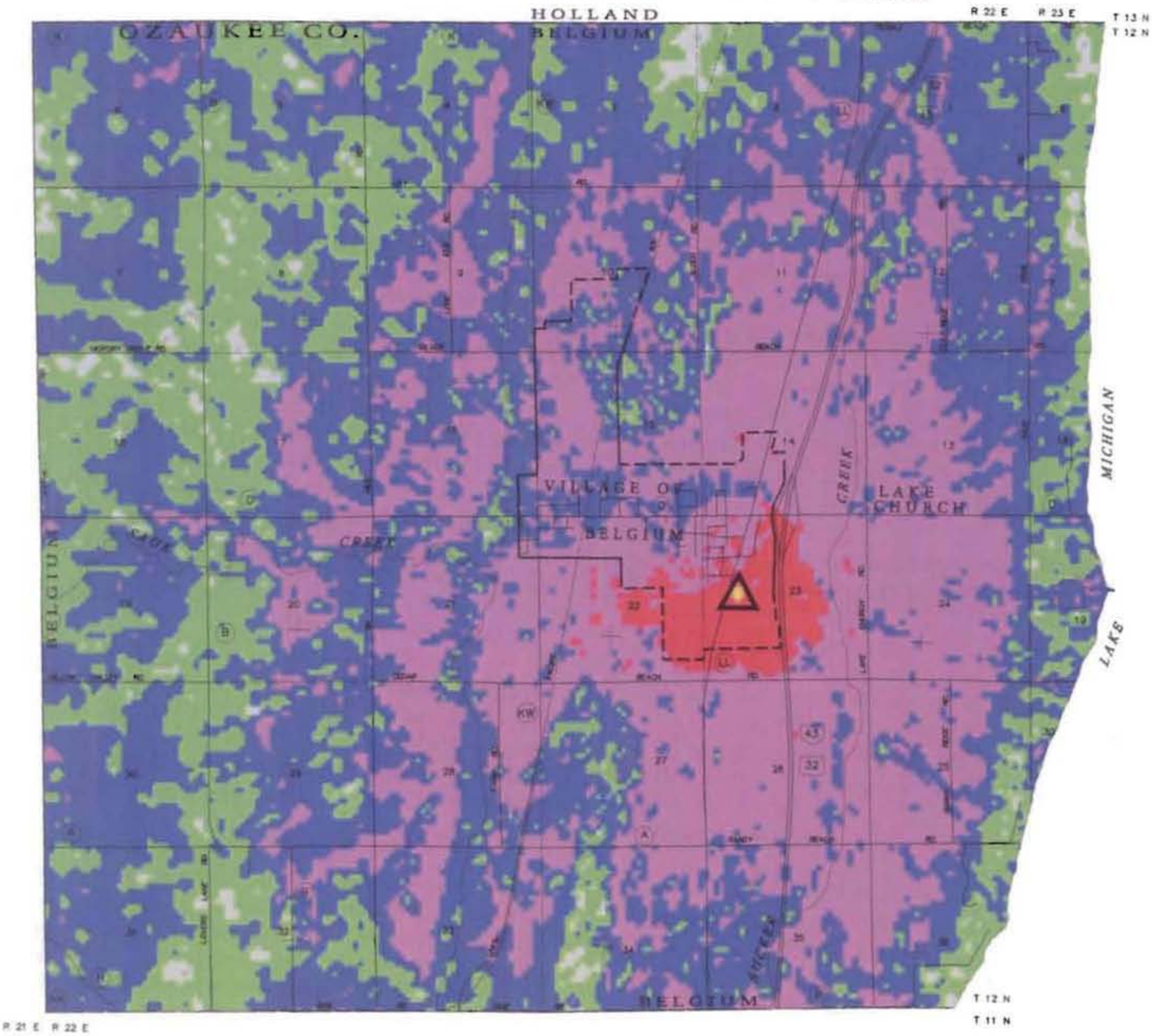
The overall conclusion at this time regarding athermal effects of radio frequency radiation must be that adverse health effects have not been demonstrated sufficiently to establish maximum permissible exposure (MPE) limits lower than those specified for thermal affects. One factor, however, is certain lower power communication is beneficial for all effects of radio frequency radiation. For this reason, the Commission's planning efforts have continually emphasized low power transmission supported by high sensitivity reception as the key to minimizing the environmental impact of wireless communications.

Other Environmental Impacts

This review of the environmental effects of radio frequency radiation has concentrated exclusively on human health impacts. There are however, two other environmental consequences of radio frequency radiation that should be noted.

A major consequence of the growth of cellular wireless communications and the proliferation of cell phone users and WiFi "hot spot" locations has been radio frequency interference. The 2.4 GHz unlicensed frequency band used in WiFi networks is also used by microwave ovens and many cordless phones. WiFi systems operate in unlicensed bands which are open to all users, so that interference becomes a major issue. Private cellular networks typically employ licensed frequency bands that are exclusive for the licensed operator. These systems, because they operate at higher transmit power levels, can also be a source of interference to other frequency bands based on the harmonic signals they generate. Harmonics are integer multiples of the base frequency that are generated and transmitted along with the base frequency. For example, an 800 MHz transmitter could generate harmonics at 1600 MHz and 2400 MHz. The second harmonic at 2400

FIELD STRENGTH OF SIGNAL AT REMOTE ANTENNA
USING EXISTING FREQUENCY OF 891 Mhz AND 100 WATTS OF
POWER IN THE VILLAGE OF BELGIUM AND THE TOWN OF BELGIUM



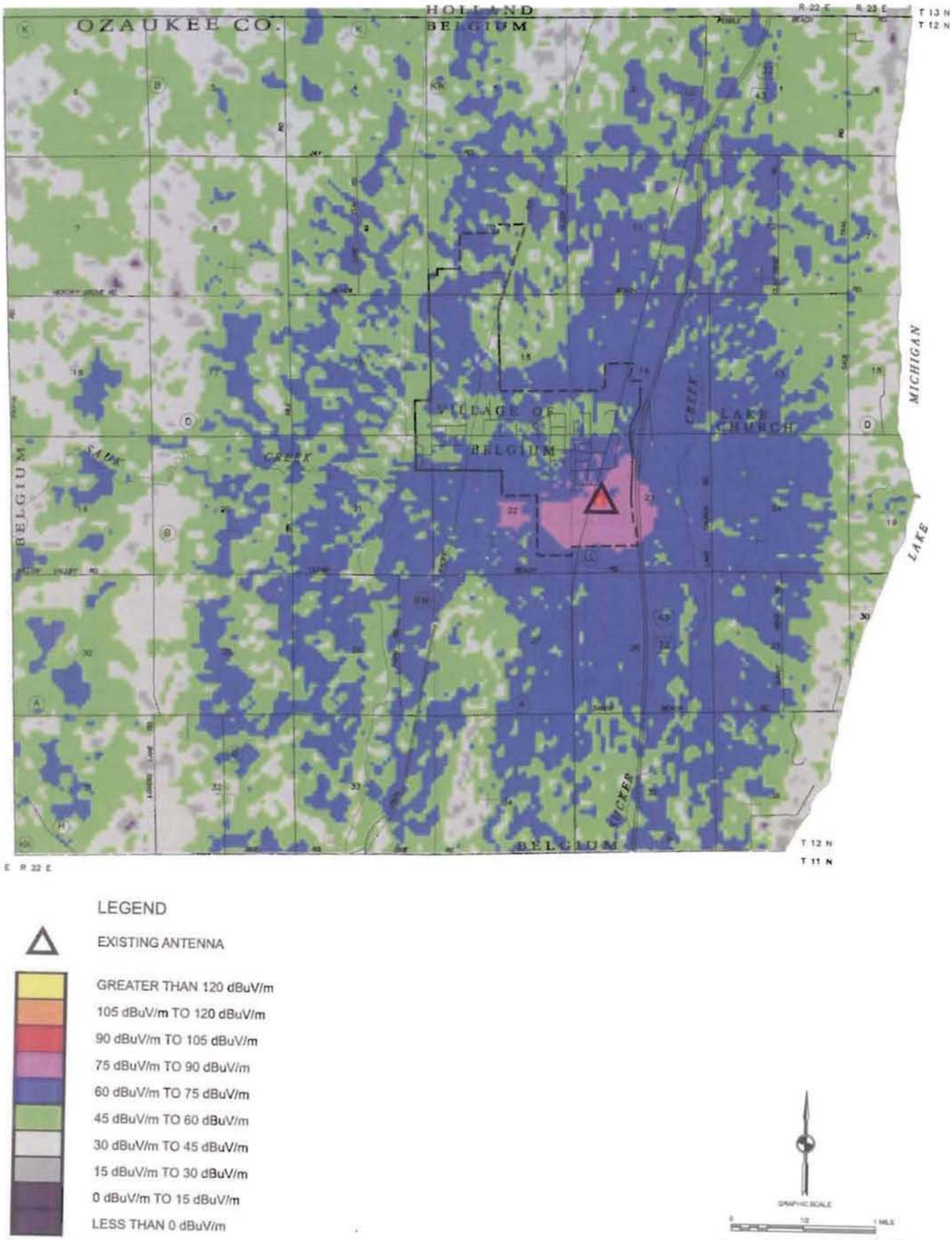
LEGEND

EXISTING ANTENNA

GREATER THAN 120 dBuV/m
105 dBuV/m TO 120 dBuV/m
90 dBuV/m TO 105 dBuV/m
75 dBuV/m TO 90 dBuV/m
60 dBuV/m TO 75 dBuV/m
45 dBuV/m TO 60 dBuV/m
30 dBuV/m TO 45 dBuV/m
15 dBuV/m TO 30 dBuV/m
0 dBuV/m TO 15 dBuV/m
LESS THAN 0 dBuV/m

Source: SEWRPC.

FIELD STRENGTH OF SIGNAL AT REMOTE ANTENNA
USING PROPOSED FREQUENCY OF 2400 Mhz AND 4 WATTS OF
POWER IN THE VILLAGE OF BELGIUM AND THE TOWN OF BELGIUM



Source: SEWRPC.

Table A-1

COMPARISON OF RADIATION EXPOSURE LIMITS, COMPUTED VALUES AND MEASURED VALUES: SEPTEMBER 2006

Type	Frequency (Megahertz)	Standard		Computed		Measured	
		Power Density (watts per meter^2)	Field Strength (volts per meter)	Power Density (watts per meter^2)	Field Strength (volts per meter)	Power Density (watts per meter^2)	Field Strength (volts per meter)
Cellular/PCS	1,932	9.5	59.8	0.00079	0.54	0.000120	0.213
WiFi/WiMAX	2,400	10.0	61.4	0.00030	0.34	0.000051	0.139

Note: Radio propagation computations and field measurements are based on radiation levels 100 meters from the antenna location.

Source: SEWRPC.

MHz could interfere with WiFi communications. Responsible communications practices recommend the conservation of transmit power in the interest of other users. The golden rule of wireless communications is to utilize only the transmit power necessary to reliably serve the network. Excess transmit power contributes to the electronic pollution of the airwaves. Radio interference is currently the limiting factor in most wireless communications systems. The low power wireless systems advocated in this plan serve to free up the airwaves for higher communication performance.

Another environmental benefit of low power communications relates to its potential use of renewable power sources. Solar panels and their associated photovoltaic cells and rechargeable batteries are particularly attractive low power sources for network access points. Small solar power units have been developed that are capable of operating in overcast weather for very extended periods. Use of solar power also provides for a lower cost, more reliable and robust network.

Summary

A combined theoretical and experimental investigation of the environmental impact of radio frequency (RF) radiation generated by existing and planned wireless communications systems in Southeastern Wisconsin confirms that all are in compliance with maximum permissible exposure (MPE) limit standards published by the Federal Communications Commission. These standards are based on the thermal effects of radio frequency on the human body. Some epidemiological and laboratory investigations of athermal effects of radio frequency radiation have indicated possible adverse effects on human health, but the results of these studies have not been sufficiently confirmed to allow for standards lower than those already established for thermal effects. In the absence of conclusive recommendations on athermal effects, the Commission staff recommends the deployment of low power wireless communications systems that will not only tend to minimize radio frequency radiation effects on human health, but also reduce electronic pollution of the airwaves and allow for low power renewable energy sources such as solar cells.

Appendix B

GLOSSARY

GLOSSARY

Term	Definition
1G	First generation wireless technology: Analog technology, introduced circa 1983.
2G	Second generation wireless technology: Digital technology, introduced circa 1992.
2.5G	Second and a half generation wireless – 2G digital technology plus added feature of GPRS (General Packet Radio Service).
3G	Third generation wireless technology: Broadband, high speed, digital technology, currently being introduced.
4G	Fourth generation wireless technology: Advanced broadband, high speed, digital technology, anticipated to be introduced circa 2007.
Access Network	A network that connects users to a core network such as the Internet.
ADSL	A symmetrical Digital Subscriber Line
Advanced Broadband	The FCC defines advanced broadband as service providing data transmission at a rate of at least 200 kilobits per second in both directions.
AMPS	Advanced Mobile Phone Service. Another word for the North American analog cellular phone system.
Antenna Site	A geographic location used for an antenna structure.
Antenna Structure	The tower, mast or other support on which antenna are mounted together with the radiation system and attendant appurtenances.
Antenna	A device for transmitting, receiving or transmitting and receiving radio frequency signals.
AT&T	American Telephone & Telegraph Company: Prior to 1984, AT&T was the major telephone service provider and equipment manufacturer in the U.S. Broken up by court decree in 1984, the Company became a long distance service provider and eventually spun off its manufacturing arm in a series of divestitures. Both the wireline and wireless components of the company have been acquired by the old SBC (Southwestern Bell) which has renamed itself the "New AT&T".
ATM	Asynchronous Transfer Mode: ATM service was developed to allow one communication medium (high speed packet data) to provide for voice, data and video service. During the 1990s, ATM became a standard for high-speed digital backbone networks. ATM networks are widely used by large telecommunications service providers to interconnect their network parts (e.g., DSLAMs and Routers). ATM aggregators operate networks that consolidate data traffic from multiple feeders (such as DSL lines and ISP links) to transport different types of media (voice, data and video).

Term	Definition
AON	Active Optical Network
Base Station	A fixed station used for communicating with mobile stations most commonly handsets. Fixed stations usually consist of an antenna site, antenna structure, antennae and supporting electronic and electric power facilities.
Backhaul Network	A wireless or wireline communications network that transports access points to gateways for Internet interconnection.
Bluetooth	A standard for short range wireless personal area networks (IEEE 802.15.1). Operates in the 2.45 GHz unlicensed frequency band.
B-ONT	Business Optical Network Terminal
Broadband	In general, any telecommunications connection to a user providing transmission at a rate of at least of 256 kilobits per second or more is considered broadband Internet. The official International Telecommunications Union Standardization Section (ITU-T recommendation I.113 has defined broadband as a transmission capacity that is faster than ISDN, at 1.5 to 2 megabits per second. It should be noted, however, that there is no international uniformity with respect to the definition of the term "Broadband," for example, the United States FCC definition of broadband is 200 kilobits per second in one direction, while the country of South Korea defines as broadband a telecommunication connection providing a transmission rate of over 50 megabits per second."
CDMA	Code Division Multiple Access.
CLEC	Competitive Local Exchange Carriers: The term was coined by the Telecommunications Act of 1996 and refers to an organization that competes with the incumbent, i.e., a former monopoly local phone company.
CO	Central Office: The CO is the location which houses switches and routers to serve local telephone subscribers.
Core Network	A combination of high-capacity switches and transmission facilities which form the backbone of a carrier network. End users gain access to the core of the network from access networks.
dBi	Decibals isotropic. A unit of gain applied to antennas, both directional and omnidirectional.
dBmW	Decibel Milliwatts
DMT	Discrete multi-tone
DNS	Domain Name Service.
DSL	Digital Subscriber Line: A generic name for a family of technologies (also called xDSL) being provided by local telephone companies for high speed data services.

Term	Definition
DSLAMS	Digital Subscriber Line Access Multiplexers in DSL networks.
DSSS	Direct Sequence Spread Spectrum. RF modulation technique that uses algorithms to code transmissions in sequential channels and then decodes them in the receiving end.
DWDM	Dense Wave-Length Division Multiplexing: A version of fiberoptic communication that combines many optical channels on a single fiber to increase the data transmission capacity of the fiber. Dense wave division multiplexing provides a significant increase to wave division multiplexing (WDM) that combines up to four different optical channels (different wavelengths) on a single fiber. As of 2001, DWDM systems provided for 8 to 80 different wavelengths with the capability of transferring over 1 trillion bits of data per second (Tbps).
EHF	Extremely High Frequency: The band of microwave frequencies between the limits of 30 GHz and 300 GHz (wavelengths between 1 cm and 1 mm).
Ethernet	An access control method based on IEEE standard 802.3.
EV-DO	Evolutionary Data Optimized – a cellular wireless technology.
FAA	Federal Aviation Administration
FCC	Federal Communications Commission: The federal organization set up by the Communication Act of 1934 to regulate all interstate (but not intrastate) communications in the U.S.
FHSS	Frequency Hopping Spread Spectrum. A technique used in spread spectrum radio transmission systems, such as Wireless LANs and some PCS cellular systems. FHSS involves hopping rapidly from one frequency at another to avoid jamming or eavesdropping.
FSO	Free Space Optical: FSO refers to wireless telecommunications transmission in the infrared frequency bands in the 800-1600 nanometer wavelength range.
FTTC	Fiber-to-the-Curb: A hybrid transmission system which involves fiber optic links to the curb and either twisted pair or coaxial cable to the premises.
FTTH	Fiber-to-the-Home: A transmission system in which optical fiber is carried all the way to the customer's premises.
FTTN	Fiber-to-the-Node: A hybrid transmission system involving optical fiber from the carrier network to a neighborhood node. The connection from the neighborhood node to individual homes may be wireless or involve legacy twisted pair or coaxial cable.
FTTP	Fiber-to-the-premises: another name for fiber-to-the-home.
FTTU	Fiber-to-the-user

Term	Definition
Gateway Base Station	Base station with an Internet connection.
GEO	Geosynchrous Satellite
GHz	Gigahertz: A unit of frequency denoting one billion Hertz (Hz) or one billion cycles per second.
GIS	Geographic Information System: Computer applications involving the storage and manipulation of maps and related data in electronic format.
GSM	Global System for Mobile Communications. The standard digital cellular phone service found in Europe, Japan, Australia and elsewhere – a total of 85 countries.
GPRS	General Packet Radio Service
Hertz	Cycles per second named after German physicist, Heinrich Hertz.
HFC	Hybrid Coax-Fiber Optic Cable: An advanced CATV (cable television) transmission system that uses fiber optic cable for the head end and feeder distribution system and coaxial cable for the customer's end connection. HFC are the 2nd generation of CATV systems. They offer high-speed backbone data interconnection lines (the fiber portion) to interconnect end user video and data equipment. Many cable system operators anticipating deregulation and in preparation for competition began to upgrade their systems to HFC systems in the early 1990s. As of late 2000, over 35 percent of the total cable lines in the United States had been converted to HFC technology.
H-ONT	Home Optical Network Terminal
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
HTTP	Hyper Text Transfer Protocol – text or graphic.
HTTPS	The secure version of HTTP.
iDEN	Integrated Dispatches Enhanced Network
IEEE	Institute of Electrical and Electronic Engineers: Founded in 1884 as the AIEE (American Institute of Electrical Engineers), it later merged (circa 1960s) with the Institute of Radio Engineers (IRE) to become the world's largest technical professional society renamed the IEEE. It sponsors technical symposia, conferences and local meetings and publishes technical papers. In telecommunications, it is best known for the publication of standards such as the 802 series for local area networks.